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(19)

(54) APPARATUS FOR USE IN STORING BODY TISSUE

(71) We, VICKERS LIMITED, of Vickers House, Millbank Tower, Millbank, London SW1 a British company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for use in storing body tissue.

According to one aspect of the present invention, there is provided apparatus for use in storing body tissue, comprising a vessel for receiving body tissue to be stored, the vessel having an inlet and an outlet for enabling liquid perfusate to enter and leave the vessel respectively, and also comprising pump means of the kind defining a pumping passageway along which liquid perfusate is forced when the pump means are operated by a source of operating power therefor, duct means connecting the said outlet to one end of the pumping passageway and the other end of the pumping passageway to the said inlet to define with the interior of the vessel and the pumping passageway a fluid circuit around which liquid perfusate is circulated when the apparatus is in use and the pump means is operated, the pump means being adapted to be connected to such a source of operating power when the apparatus is in use in such a manner that the source can be disconnected from the pump means after such use.

According to another aspect of the present invention, there is provided apparatus for use in storing body tissue, comprising a vessel for receiving body tissue to be stored, the vessel having an inlet and an outlet for enabling liquid perfusate to enter and leave the vessel respectively, and also comprising duct means connecting the said outlet to the said inlet externally of the said vessel to form with the interior of the vessel a fluid circuit, and pump means provided with a source of operating power and operable when the apparatus is in use to drive liquid perfusate to circulate around the fluid circuit from the said inlet, through the interior of the vessel to the said outlet, through the duct means back to the said inlet, and so on, portions of the apparatus, including the pump means, which come into contact with liquid perfusate in the fluid circuit when the apparatus is in use being detachable from other portions of the apparatus, including the source of operating power, which do not come into contact with liquid perfusate in the fluid circuit so that the said portions which come into contact with perfusate can be discarded after use whilst the said other portions can be retained for further use.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:—

Figure 1 shows a first form of non-hyperbaric perfusion apparatus for the preservation of kidneys, and

Figure 2 shows a second form of non-hyperbaric perfusion apparatus for the preservation of kidneys.

In the two Figures like reference numerals indicate like components.

The apparatus shown in Figure 1 comprises a vessel 1 for containing a kidney 2 supported in the vessel on a coarse filter 3. The vessel has a lid 4 and is provided with an inlet duct and an outlet duct. The inlet duct passes through the wall of the vessel 1 and is connected to the kidney. The outlet duct opens from the base of the vessel and is connected to the inlet duct externally of the vessel by way of a reservoir 5 incorporating a fine filter 6, a perfusion pump 7, the primary side of a heat ex-

changer 8, an oxygenator 9, and a flow-rate meter 10 of the tube and float type. The apparatus is provided with a flow-control throttle 11, a source 12 of operating power for the pump connected by way of a connection 19 to a pump 7 for actuating the pump, a cooling device 13 connected to supply cold water to the secondary side of the heat exchanger 8, and a manometer 14.

The pump 7 is a tube pump comprising two compressible tubes connected in parallel with one another and each provided with a non-return valve at each end, and means whereby the tubes may be alternately compressed to expel liquid therefrom and released to enable more liquid to enter. The two tubes may be compressed and released in time with one another to provide a pulsing flow of liquid, or one compressed while the other is released to provide a more uniform flow. To achieve the compression and release of the tubes, the tubes may be mounted in a sealed chamber connected through an inlet valve to a source of compressed gas and through an outlet valve to the atmosphere, the valves being arranged to close and open alternately thereby to pressurise and de-pressurise the chamber. In the case of the more uniform flow being required, each tube is mounted in its own sealed chamber. In each of these cases the or each sealed chamber is part of the pump 7 and the source 12 of operating power is the source of compressed gas, the connection 19 between the pump 7 and the source 12 being pneumatic. An alternative way of operating the pump is to employ two double-acting pneumatic cylinders having their pistons connected to respective hinged flaps which are so mounted that when the cylinders are operated in one sense the flaps engage the tubes 18 and compress them and when the cylinders are operated in the other sense the flaps release the tubes and enable them to fill once more. In this case, the source 12 of operating power includes the pneumatic cylinders. The hinged flaps may be parts of the pump 7 or the source 12. The connection 19 between the pump 7 and the source 12 is mechanical. Instead of being operated mechanically or pneumatically, the pump may be operated hydraulically or electropneumatically.

The cooling device 13 comprises a container 20 for containing ice and a pump 21 for circulating water through the container 20 and the secondary side of the heat exchanger 8. The circulating water cools the perfusate flowing through the primary side of the heat exchanger and is kept cold by the ice gradually melting. The flow-control throttle 11 comprises a pair of members 16 and 17 mounted at opposite sides of a section of yieldable duct, not forming part of the flow control throttle, between the flow-rate meter 10 and the inlet to the vessel 1. The members 16 and 17 can be urged towards one another to pinch the yieldable duct to a variable degree, thereby to vary the rate at which perfusate liquid is delivered to the vessel 1.

The manometer 14 is in two parts 22 and 23, the part 22 being contacted by liquid perfusate and comprising a rigid plastics material tube 24 having an opening at each end, the openings being separated from each other by a slack diaphragm 25, and the other part 23 not being contacted by liquid perfusate and comprising an inlet tube 26 connected with an aneroid manometer 27 and provided with a tap 28 for zeroing pressure. One end of the tube 24 is permanently connected with the inlet duct connected to the kidney 2 in the vessel 1, and the other end of the tube 24 is releasably connected with the tube 26. Since the diaphragm 25 is slack the pressure on both sides thereof is the same so the aneroid manometer 27 provides a measure of the pressure of liquid perfusate in the duct connecting the flow-control throttle with the inlet to the vessel 1.

When the apparatus is in use the pump 7 drives liquid perfusate to circulate through the primary side of the heat exchanger 8, the oxygenator 9, the flow-rate meter 10, the flow-control throttle 11, the kidney 2, the vessel 1, the reservoir 5, and the pump 7. The circulating perfusate is cooled in the heat exchanger 8 and is oxygenated in the oxygenator 9. The rate of flow of perfusate is monitored by means of the meter 10 and is controlled by means of the throttle 11. The pressure of the circulating perfusate is monitored by means of the manometer 14. On passing through the kidney the perfusate gives up some of its oxygen to the kidney 2. Solid impurities which become entrained in the circulating perfusate are removed by means of the filters 3 and 6. Alternatively, the fine filter may be provided after the pump in the circuit rather than before it.

The vessel 1, including the coarse filter 3 and the lid 4, the reservoir 5, including the fine filter 6, the pump 7, the heat exchanger 8, the oxygenator 9, the flow-rate meter 10, the part 22 of the manometer, and the connection 19, *i.e.* all the components (except the flow-control throttle 11 and the connection 19) which lie inside the dot-dashed line in Figure 1, and all the ducting connecting these components, come into contact with perfusate liquid when the apparatus is in use, whereas the source 12, the connection 19, the cooling device 13, the flow-control throttle 11 and the part 23 of the manometer do not. The components

which do not come into contact with perfusate liquid when the apparatus is in use are connected to the components which do by plug-in connections, shown in Figure 1 by short thick lines, and accordingly they can be disconnected from these other components. Thus, the components which are not contaminated by perfusate liquid when the apparatus is in use can be retained for further use after the contaminated components have had to be discarded.

The apparatus shown in Figure 2 differs from that shown in Figure 1 insofar as the vessel 1 incorporates a heat exchanger and accordingly there is no need for the heat exchanger 8 shown in Figure 1. Thus, the vessel 1 contains an internal cooling jacket 29 surrounding the kidney and having an inlet and an outlet connected to the cooling device 13 by way of plug-in connections so that water from the device 13 can be circulated by the pump 21 through the internal cooling jacket of the vessel 1 and thereby cool the perfusate liquid in the vessel.

Both the illustrated forms of apparatus are made using two sheets of plastics material welded together along selected lines to provide the necessary ducting. Some of the components, other than the ducting, which are contaminated by perfusate liquid when the apparatus is in use are also formed from the two sheets, whilst other such components are welded to or between the two sheets.

Both the illustrated forms of apparatus are used non-hyperbarically, but an hyperbaric perfusion apparatus may be produced by constructing the apparatus so that the circuit can be pressurised.

In a modification of the apparatus the oxygenator 9 may be dispensed with.

WHAT WE CLAIM IS:—

1. Apparatus for use in storing body tissue, comprising a vessel for receiving body tissue to be stored, the vessel having an inlet and an outlet for enabling liquid perfusate to enter and leave the vessel respectively, and also comprising pump means of the kind defining a pumping passageway along which liquid perfusate is forced when the pump means are operated by a source of operating power therefor, duct means connecting the said outlet to one end of the pumping passageway and the other end of the pumping passageway to the said inlet to define with the interior of the vessel and the pumping passageway a fluid circuit around which liquid perfusate is circulated when the apparatus is in use and the pump means is operated, the pump means being adapted to be connected to such a source of operating power when the apparatus is in use in such a manner that the source can be disconnected from the pump means after such use.

2. Apparatus for use in storing body tissue, comprising a vessel for receiving body tissue to be stored, the vessel having an inlet and an outlet for enabling liquid perfusate to enter and leave the vessel respectively, and also comprising duct means connecting the said outlet to the said inlet externally of the said vessel to form with the interior of the vessel a fluid circuit, and pump means provided with a source of operating power and operable when the apparatus is in use to drive liquid perfusate to circulate around the fluid circuit from the said inlet, through the interior of the vessel to the said outlet, through the duct means back to the said inlet, and so on, portions of the apparatus, including the pump means, which come into contact with liquid perfusate in the fluid circuit when the apparatus is in use being detachable from other portions of the apparatus, including the source of operating power, which do not come into contact with liquid perfusate in the fluid circuit so that the said portions which come into contact with perfusate can be discarded after use whilst the said other portions can be retained for further use.

3. Apparatus according to claim 1 or 2, wherein said duct means consists, at least in part, of ducting comprising two sheets of plastics material welded together along selected lines.

4. Apparatus according to any preceding claim, wherein said pump means is pneumatically operated.

5. Apparatus according to claim 4, wherein said pump means comprises two compressible tubes connected in parallel with one another and each provided with a non-return valve at each end, and means whereby the tubes may be alternately compressed to expel liquid perfusate therefrom and released to enable more liquid perfusate to enter.

6. Apparatus according to claim 5, wherein said pump means is so arranged that said tubes may be compressed and released in time with one another to provide a pulsing flow of liquid perfusate.

7. Apparatus according to claim 5, wherein said pump means is so arranged that one of said tubes may be compressed while the other is released to provide a substantially uniform flow of liquid perfusate.

8. Apparatus according to any one of claims 5 to 7, wherein said means whereby said tubes may be alternately compressed and released comprises a sealed chamber in which said tubes are mounted and which has a first connection for said source of operating power, having an inlet

valve, and a second connection, having an outlet valve and leading to atmosphere.

9. Apparatus according to any preceding claim, wherein said duct means includes an oxygenator for oxygenating the liquid perfusate.

10. Apparatus according to any preceding claim, wherein said duct means includes filter means for removing solid impurities from the liquid perfusate.

11. Apparatus according to any preceding claim and further comprising means for cooling the liquid perfusate.

12. Apparatus according to claim 11 when appended to claim 2, wherein said means for cooling the liquid perfusate comprises a heat exchanger having primary and secondary sides of which the primary side is connected in said fluid circuit, and a cooling device releasably connected to the secondary side of the heat exchanger.

13. Apparatus according to claim 11 when appended to claim 2, wherein said means for cooling the liquid perfusate comprises an internal cooling jacket arranged in said vessel and a cooling device releasably connected to the cooling jacket.

14. Apparatus according to claim 2 or any dependent claim thereof when appended thereto wherein said duct means includes means for measuring the pressure of said liquid perfusate.

15. Apparatus according to claim 14 when appended to claim 2, wherein said means for measuring the pressure of said liquid perfusate comprises a two-part manometer of which one part comprises a tube, one of whose openings, which are separated by a slack diaphragm, is in connection with said duct means, and of which manometer the other part also comprises a tube, which tube is releasably connected to the first mentioned tube and is provided at its free end with an aneroid barometer.

16. Apparatus according to claim 2 or any dependent claim thereof, wherein the first mentioned portions of the apparatus are detachable from the second mentioned portions of the apparatus by means of plug-in connections between said first and second mentioned portions.

17. Apparatus for use in storing body tissue, substantially as hereinbefore described with reference to and as illustrated by Figure 1 or Figure 2 of the accompanying drawings.

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1 422 356 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

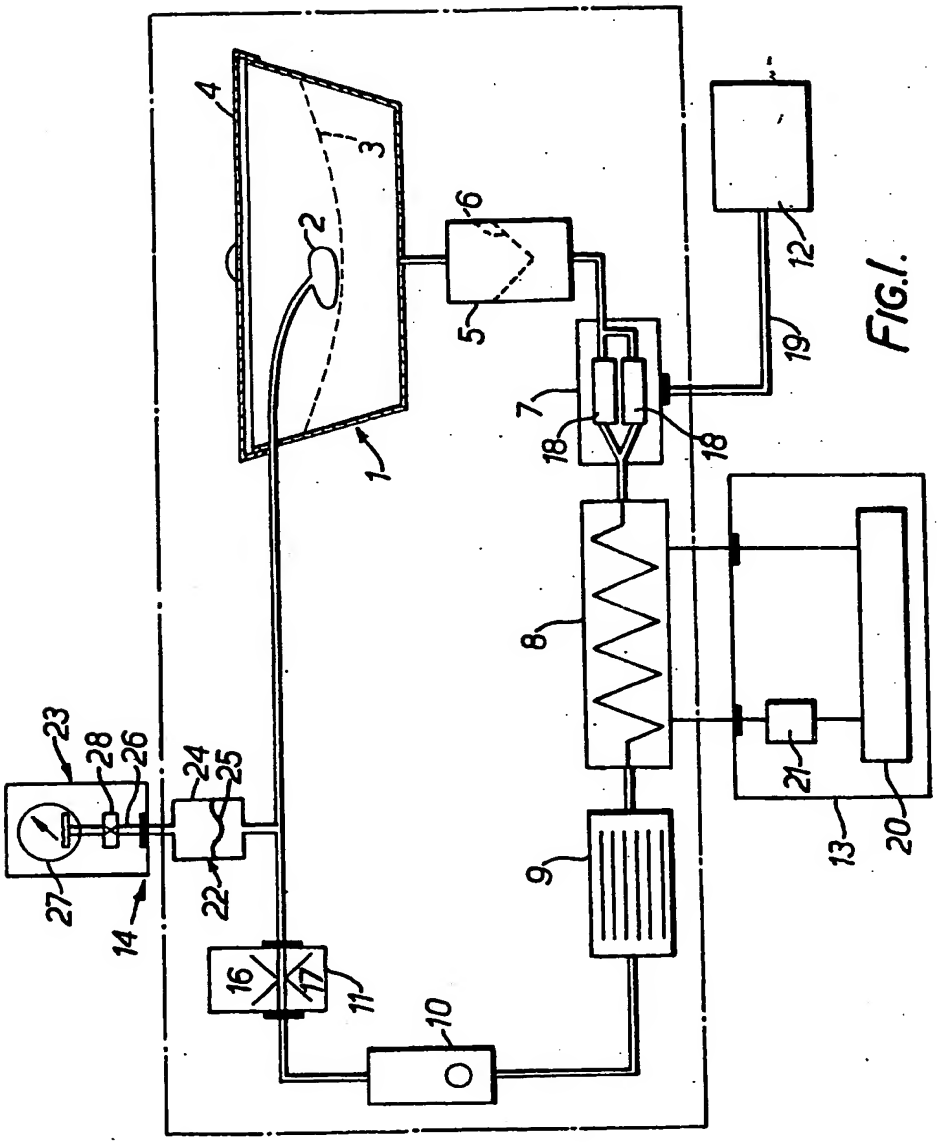

FIG.1.

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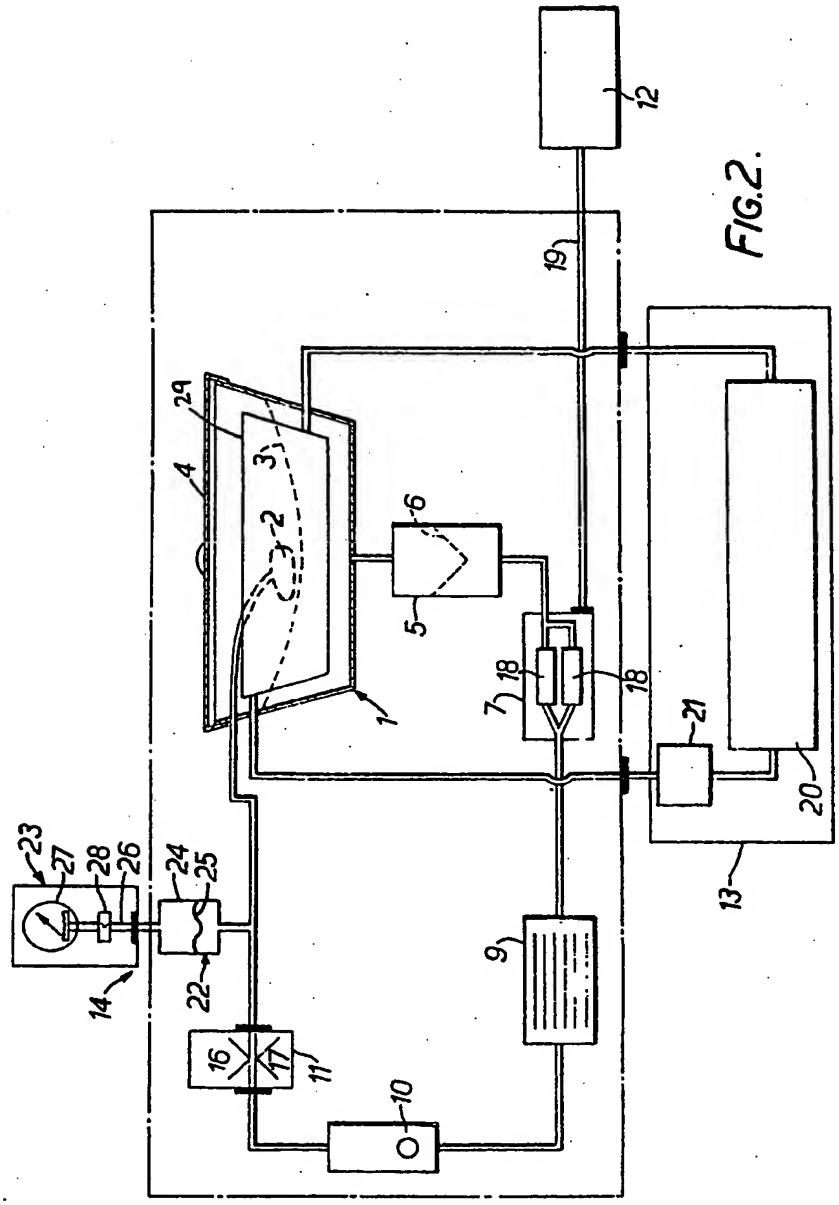

FIG.2.